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Effects of water availability on the germination of native and exotic forbs

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Introduction

The shifting climate of semi-arid grasslands in the Intermountain west is expected to continue to generate decreases in annual rainfall, and prolong rain-free windows of time into time periods where rainfall has been previously abundant.

Understanding how differences in water availability influence the phenology of seed germination will allow us to better gauge how plant species will persist and how plant populations will recover in response to restoration efforts.

Additionally, differences in the response of native and exotic plant species will further guide land management and restoration efforts.

Native	Exotic
Achillea millefolium (a)	*Centaurea stoebe* (g)
Antennaria rosea (b)	*Linaria vulgaris* (h)
Arnica montana (c)	*Potentilla recta* (i)
Gaillardia aristata (d)	*Sisymbrium altissimum* (j)
Heterotheca villosa (e)	
Penstemon procerus (f)	

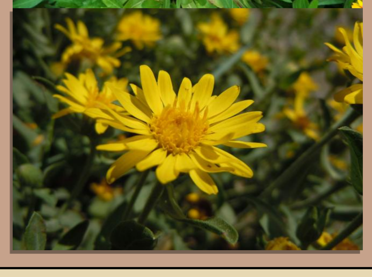
(a)

(b)

(c)

(d)

(e)



(f)

(g)

(h)

(i)

(j)

Methods

For each plant species, we filled twelve Petri dishes with two pieces of filter paper and divided these dishes into three groups of four. We added low (1.5mL), medium (2.5mL), or high (3.5mL) amounts of water to each set of dishes to vary seed water availability. Dishes were watered daily with 0.7mL, 1.0mL, or 1.5mL of water to maintain low, medium, and high water levels, respectively. Eight seeds of a single species were placed into each dish and dishes were placed into a growth chamber (12 hrs light at 20C and 12C during darkness), monitored and rotated daily.

All analyses were conducted in R version 3.5.1. To test the effects of plant origin (native or exotic), plant species, and water treatment (low, medium, or high) on seed germinability, germination synchrony, and the time to germination, we used generalized linear mixed-effects models. Since we used different numbers of native and exotic plant species, we ran two separate GLMMs for each response variable (six GLMMs total). In these models, dish was treated as a random factor and species and water treatment or origin and water treatment were treated as fixed effects.

Results

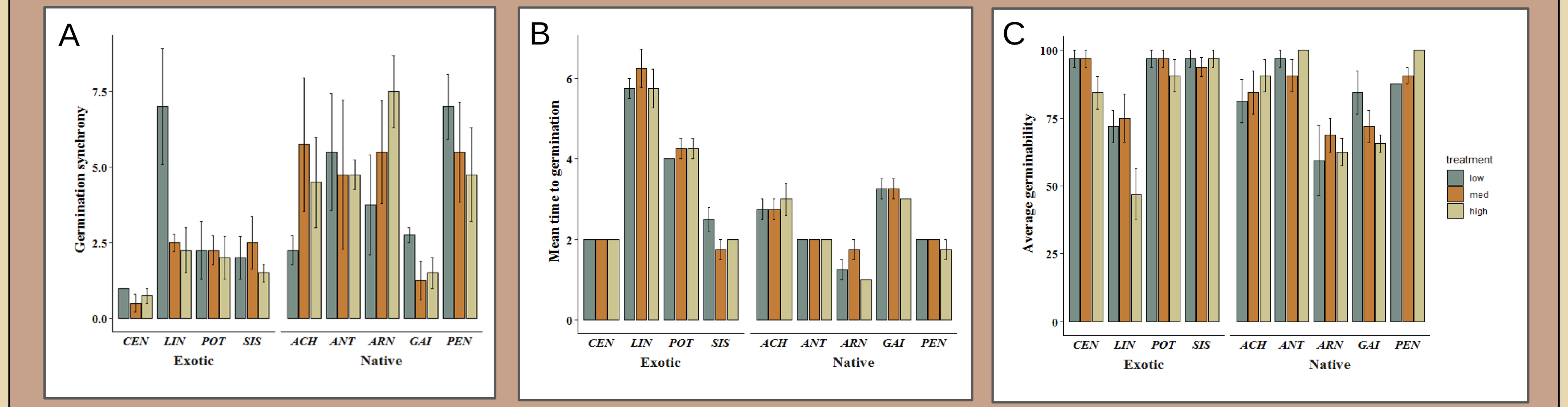


Figure 1. Effects of low (gray), medium (orange) or high (tan) water levels on germination synchrony (A), mean time to germination (B), and average seed germinability (C) across nine native and exotic forbs.

We found differences across species in germination synchrony (x^2 = 117.8, $p < 0.001$). Additionally, germination synchrony was affected by an interaction between species and water treatment (x^2 = 27.10, p = 0.040) suggesting that seed water availability may influence the synchrony of germination for plant species in different ways.

Differences across species were also observed in mean time to germination (x^2 = 1244, $p <$ 0.001) and a significant interaction between species and water treatment (x^2 = 39.26, $p <$ 0.001) suggests that differing water availabilities can have species-specific effects on the timing of germination. The mean day of germination differed for native and exotic species (x^2 = 32.74, $p <$ 0.001) with exotic species germinating on average one day later than native species.

Seed germinability varied significantly across species (x^2 = 165.4, $p < 0.001$) and water treatment (x^2 = 19.32, $p < 0.001$) but not by origin.

Discussion

In dryland ecosystems, seed germination ushers in a period of acute vulnerability for young seedlings which over a short time period will face multiple impediments to survival. The intensity of this challenge is reflected in the low number of spring germinating seedlings that survive through their first summer in dryland systems. Dryland plants are expected to have functional traits that promote faster seedling growth and the phenological ability to match germination timing with precipitation opportunities to increase the probability of recruitment during precipitation windows. Since few studies have evaluated these early establishment traits, we have little understanding of their patterns or relationships. Additionally, the proliferation of exotic over native plant species following disturbances in drylands suggests that the traits of invasive species' seeds and seedlings may differ from native species in a manner that contributes to their establishment.

These results reveal strong species-specific differences in seed germination for nine native and exotic forbs that are in some cases influenced by water availability. Developing a better understanding of these and other germination traits for additional dryland species could help land managers create comprehensive management and restoration strategies that encourage the establishment of native over exotic plant species under future precipitation scenarios.